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Indonesian traditional herbal drinks: diversity, processing, and health benefits

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Abstract

Indonesia has plant-based traditional medicine (herbal) that is hereditary and believed to be used for disease therapy and prevention. The well-known of this traditional medicine is jamu, which has a long history of making, and now, some have limitedly explored their benefits on health scientifically. Traditional herbal drinks are part of jamu and are usually consumed as beverages for leisure and refreshment; in addition, they are hereditary believed to have many health benefits. The health efficacy of these herbal drinks is still poorly explored scientifically. This review explores the diversity, preparation methods, and health benefits of the most popular Indonesian traditional herbal drinks, mainly in Java Island, including *kunyit asam, beras kencur, sinom, wedang uwuh, wedang jahe,* and *wedang pokak*. Combining a literature review with field observations, it highlights key bioactive compounds such as curcumin, gingerol, and brazilin, known for their antioxidant, anti-inflammatory, and antimicrobial properties. The study uniquely integrates traditional knowledge with insights into modern processing techniques, such as ultra-high temperature processing by small-scale enterprises, and examines their cultural and historical significance. By addressing the limited scientific exploration of these drinks' health benefits, this paper bridges the gap between traditional practices and scientific validation, contributing to the global understanding of functional beverages. Modern adaptations, including ultra-high temperature processing by small-scale enterprises, have enabled wider distribution and commercialization of herbal drinks. However, challenges such as maintaining bioactive compound integrity and scaling production while preserving traditional authenticity remain critical.

Keywords Bioactive compounds, Health benefits, Herbal drink, *Jamu*, Traditional medicine

Introduction

Indonesia that is considered as a mega diversity country [1] due to its highly diverse plants, animals, and microorganisms, is rich in medicinal plant resources. There are officially regulated 283 plant species for herbal medicine [2]. Hereditary, Indonesia has a traditional medicine called *jamu* (originating from the Javanese language) [3], which is made mainly from the herbs available abundantly in this country. *Jamu* is an indigenous Indonesian traditional medicine similar to Ayurveda in India and Zhongyi in China, that has been practiced for centuries from generation to generation to promote and maintain health, also treat diseases. Culturally, women consume more jamu than men, and this culture is institutionalized among communities [3] because of the belief that jamu has more beneficial health benefits for women than men. The word *jamu* comes from the ancient Javanese *djampi*, which means treatment, and *oesodo,* which means health

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[4]. *Jamu* is believed to be a healthy drink, traditionally used to maintain health, increase immunity, and treat sore throat, fever, headache, cough, nausea, lack of appetite, and aches. *Jamu* drinks such as *beras kencur*, *kunyit asam*, *sinom, wedang jahe*, *wedang pokak* (Fig. 1), and *wedang uwuh* (Fig. 2) are now popular as herbal drinks to increase health performance, and they are no longer fully associated with jamu. This review focuses on these popular herbal drinks. Based on the processing, these products are classified as herbal drinks that involve infusion or boiling the fredh herbs. Chandrasekara and Shahidi [5] defined herbal beverages can be made by infusion or boiling fresh or dried herbs, including leaves, flowers, seeds, unripe fruits, and roots.

During the COVID-19 pandemic, some people used *jamu* to treat COVID-19 infected patients [6]. During this pandemic period, the demand for popular traditional herbal drinks increased sharply. Indonesian people believe that these drinks contribute to increase the immune system; therefore, herbal drink consumption is believed to prevent COVID-19 infection [7]. Scientific studies suggest that bioactive compounds in jamu, such as curcumin and gingerol, may provide antioxidant and anti-inflammatory benefits. Public preference for these drinks over chemical-based medicine is driven by their perceived safety and cultural acceptance.

Traditional herbal drinks are made simply by boiling the herbs using kitchen utensils made from stone and burnt clay. Before boiling, the herbs are sometimes ground by using traditional stone pounders (*lumpang* or *cobek-ulekan*, Fig. 3) or slicing and then boiling in ceramic pots or pottery called *gerabah* (Fig. 3). Currently, modern processing uses blenders for grinding and stainless-steel cooking pots for boiling.

In the past, herbal drinks as part of *jamu* were sold in bottles as *jamu gendong* (*jamu* peddler) by women. *Gendong* means the bottles of jamu are put in the back during selling. *Jamu gendong* is liquid *jamu*, which is stored in bottles. The bottles of jamu are put in bamboo baskets and slung on their backs (Fig. 4). *Jamu gendong* is found in many regions of Indonesia [3]. The shift from consumption of *jamu gendong* as a healthy drink to modern herbal drinks makes the *jamu gendong* sellers are rarely found. Nowadays, herbal drinks, including *jamu,* are sold by using pushed carts (Fig. 4). Herbal drinks are sold in glasses or sometimes in bottles in case the consumers need to refill. In the past, before the glasses were introduced, *jamu* drinks were sold in coconut shells. Some

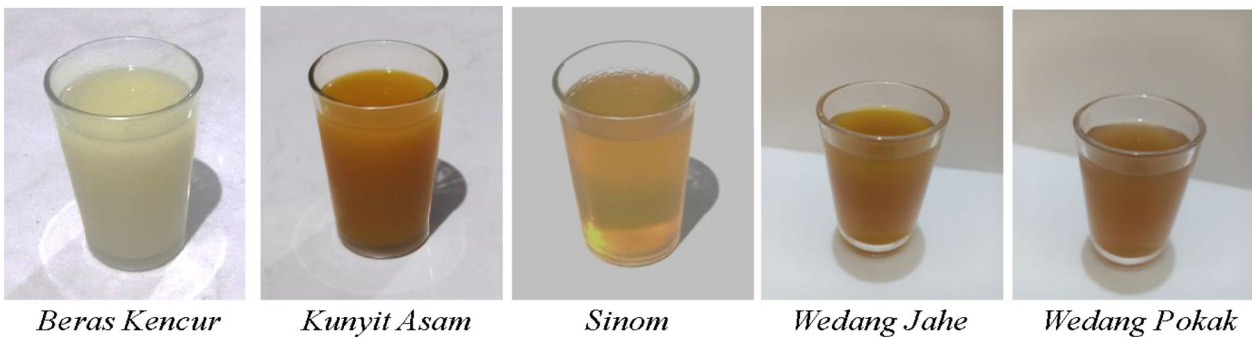

Fig. 1 Popular Indonesian traditional herbal drinks (personal documentation)

Fig. 2 Popular Indonesian traditional herbal drink *wedang uwuh*, the appearance, serving by brewing, and its ingredients (personal documentation)

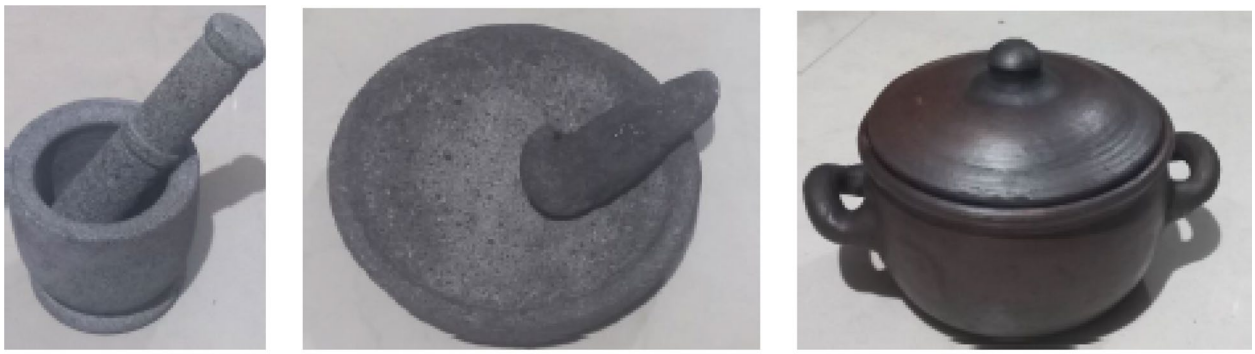

Fig. 3 Stone pounder *lumpang* (**a**) and *cobek-ulekan* (**b**) for grinding the herbs and ceramic pot (*gerabah*) (**c**) for boiling traditional herbal drinks (personal documentation)

Fig. 4 Serving herbal drinks by using coconut shell (**a**), selling by bottles in the bamboo basket (**b**) (personal documentation), and using a pushed cart (**c**) [8]

jamu gendong sellers still preserve this tradition. Most of the traditional herbal drinks are processed by household and small-scale enterprises. The herbal drinks are packaged in individual bottles. The appearances of these drinks are shown in Figs. 1 and 2. The main herb ingredients are shown in Fig. 5. All herbal drinks use palm sugar and/or cane sugar to give sweet sensation and to mask unpleasant aroma and tastes.

Currently, some Indonesian traditional herbal drinks are produced mainly by household and small-scale enterprises, and some are limitedly produced by large-scale industries with modern processing such as the combination of ultra-high temperature and aseptic packaging. The herbal drink production by household and small-scale enterprises is a transition from traditional into modern processing. The traditional utensils shown in Fig. 3 are replaced by kitchen utensils that are currently widely used such as blender to replace *lumpang* and *cobek-ulekan* (Fig. 3) and pan to replace ceramic pot (*gerabah*) (Fig. 3). The production by household and small-scale enterprises is not yet standardized and modern processing principles have not been applied. Therefore, the products have some limitation such as short shelf-life and inconsistent quality. Meanwhile, the production in large-scale industries is standardized but the efficacy of health benefits by modern processing also has not been scientifically explored.

This review explores limited scientific exploration of the most popular traditional herbal drinks, including *kunyit asam, beras kencur, sinom, wedang jahe*, *wedang uwuh*, and *wedang pokak*. The discussion is enriched by scientific evidence of the herbal drink's ingredients and

Fig. 5 Main herb ingredients for Indonesian traditional herbal drinks (personal documentation)

by examining its cultural and historical description. This review also integrates traditional knowledge with modern processing insights. Perhaps, this article will bridge traditional practices and hereditary beliefs with scientific validation that will contribute to the global understanding of herbal drinks as functional beverages.

Method of review

This manuscript is a review article enriched with observation on the producers of herbal drinks at a household scale. This observation had an Ethical Clearance from The Ethical Clearance Committee on Health Sciences, Faculty of Health Sciences, Universitas Brawijaya No. 1065/UN10.F17.10.4/TU/2024.

Observation on traditional herbal drink makers

Part of this review was based on the observations of herbal drink processing in Malang Raya, East Java (Fig. 6). The observations of processing were conducted in 3 household scale enterprises that produced the 6 most popular herbal drinks, including *kunyit asam, beras kencur, sinom, wedang pokak, wedang uwuh,* and *wedang jahe*. The observations included every step in herbal drink processing starting from raw materials to packaging. The observations also included the ingredients and formula. The precise ingredient composition of herbal drinks is not shown because the formula is a confidential. The characteristics of observed herbal drink makers are shown in Table 1.

Literature review

The literature review was performed using Google Scholar, PubMed, and institutional digital libraries, targeting peer-reviewed articles published between 2001 and 2023. Keywords such as turmeric, tamarind fruit pulp, tamarind leaves, aromatic ginger, sappan wood, ginger, lemongrass, clove, cinnamon, curcuma, yellow mangosteen, bay leaf, cardamom, pandan leaves, lime leaves, rice, nutmeg, jamu, *kunyit asam, beras kencur, sinom, wedang pokak, wedang uwuh, wedang jahe*, traditional herbal drinks, their health perception, bioactive compounds, and functional beverages were used. Most of the literature on these herbal drinks is from local scholarly journals. Articles were included if they provided relevant data on the health benefits, bioactive compounds, or processing methods of the targeted drinks. Studies unrelated to Indonesian herbal drinks or not available in full text were excluded. Findings from observations and literature were synthesized thematically, focusing on cultural practices, preparation techniques, and bioactive properties.

The result of observations: Indonesian traditional herbal drink processing and characteristics

In general, traditional herbal drink processing involves slicing or grinding the herbs, mainly the rhizomes, such as ginger, turmeric, curcuma, and aromatic ginger (Table 2). The ingredients and processing of all herbal drinks are based on observations in herbal drink makers in Malang, Indonesia. Sometimes, the rhizomes are prepared by coarse crushing, traditionally by using *lumpang* and *cobek-ulekan* (Fig. 3). All the ingredients are boiled with water with the defined composition based on the formula, then filtered and cooled. The exception is in the preparation of *wedang uwuh*, in which the processing is only by brewing all of the dried ingredients with hot water. Some traditional herbal drinks, such as *wedang jahe, wedang pokak,* and *wedang uwuh*, are served in warm condition. Table 2 presents the general processing of each herbal drink and the ingredients.

The observations of traditional herbal drink makers show that there are some variations in the formula, but generally, the processing is almost similar. The example of *beras kencur* and *kunyit asam* processing in one household scale enterprise is shown in Figs. 7 and 8. The processing in traditional makers is simple or not complicated. Processing aims to extract the herbs that are believed to contain beneficial health compounds. Sugar, mainly palm sugar, is used for sweet taste and masking undesirable flavors, such as bitterness and astringency from the ingredients.

The distinctive preparation is found in *wedang uwuh*. This herbal drink is simply prepared by brewing dried herbs such as ginger, clove, cardamom, bay leaf, lime leaf, and pandan leaf with boiled water in a glass (Fig. 2). This drink is served by brewing all ingredients with hot water to dissolve the taste and aroma of the herbs. The word *wedang* means to drink, and *uwuh* means garbage because the ingredients resemble dried leaf litter. The color of *wedang uwuh* is red resulting from sappan wood, which is rich in anthocyanin and easily dissolved in hot water. This drink is strongly aromatic, originating from pandan, lime, and bay leaves, as well as cardamom and clove. The observed *wedang uwuh* maker prepared the drink by boiling the ingredients and then filtered by a cloth to have the filtrate. The filtrate is sold as *wedang uwuh*. *Wedang uwuh* has 12 sensory attributes, including bright red color, orange-brown color, herbal aroma, ginger aroma, sweet taste, bland taste, bitter taste, spicy sensation, warm sensation, warm after-feel, bitter aftertaste, and spicy aftertaste [9].

In traditional herbal drink making, the formula, temperature, and duration of boiling and grinding are defined. There are some variations of herbal drink formula among sellers that usually preserved hereditary

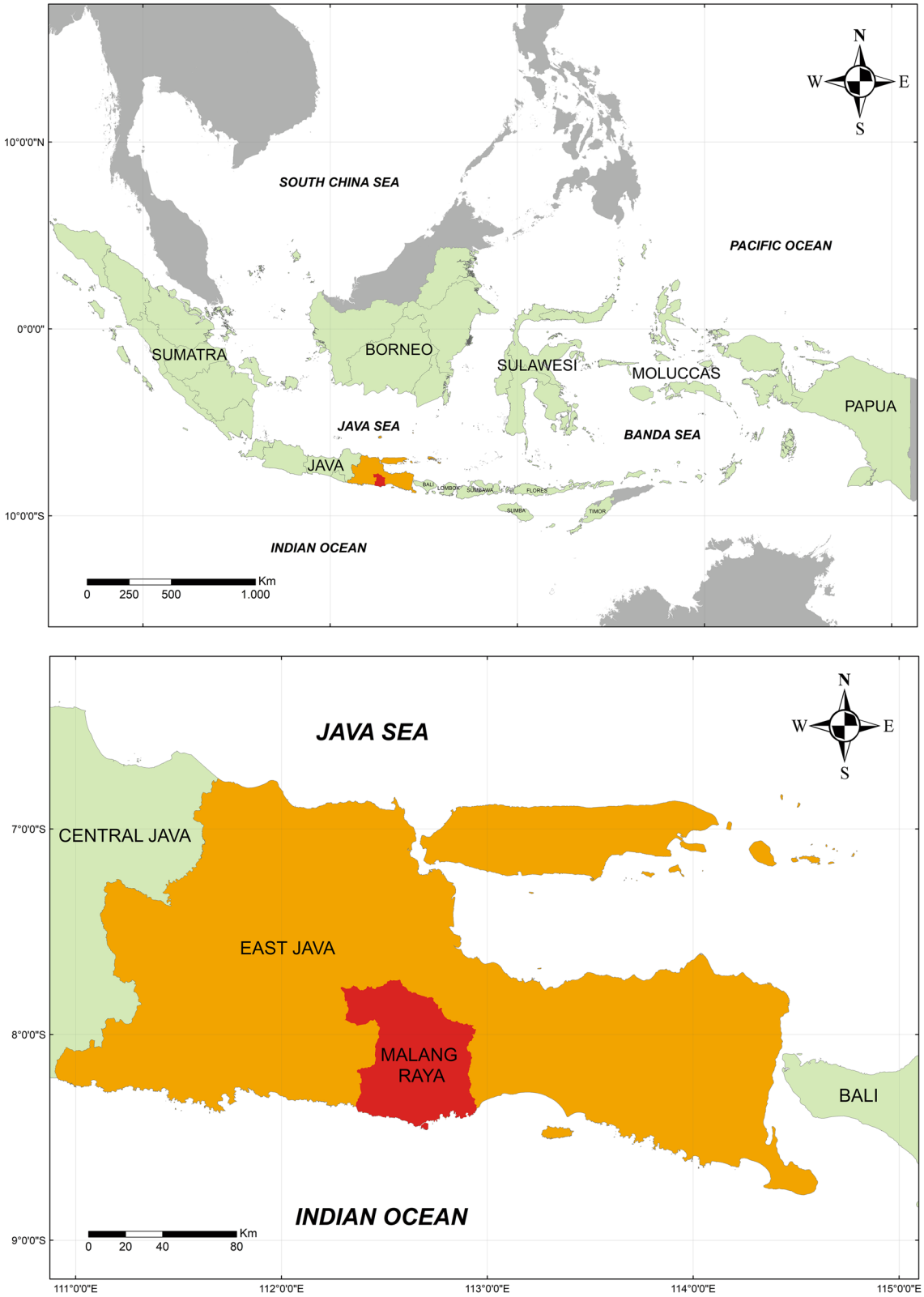

Fig. 6 Location of traditional herbal drink processing observations in Malang Raya, East Java, Java Island, Indonesia

Table 1 The characteristics of herbal drink makers at household scale enterprise

Herbal drink maker No	Product	Production capacity	Number of worker	Gender of the owner	The source of ingredients
1	*Wedang jahe*	100 L/month	2	Couple	Local market
2	*Beras kencur* *Kunyit asam* *Sinom*	30–50 L/month 30–50 L/month 30–50 L/month	1	Female	Local market
3	*Wedang pokak* *Wedang uwuh*	100 pack/month 50 pack/month	1	Male	Local market

in one family. Data in Table 2 is a generic formula commonly found in Indonesian society. People believe that if the process is not appropriate, then their health benefits will disappear. Traditionally, women have a role in *jamu* making, while men are responsible for determining and providing herbal ingredients. The tradition of jamu making has a very long history. The evidence is the finding of the artifacts of *cobek* and *ulekan* for grinding the *jamu* in one archaeological site on Sindoro Mountain, Central Java. Also, some ancient temples also have the relief of *jamu* making and their utensils [4].

Building on the historical significance of jamu, the following sections explore the specific types of herbal drinks reviewed, their preparation methods, and their bioactive compounds, emphasizing the integration of cultural heritage and modern scientific understanding.

Kunyit asam is produced by boiling the ground and turmeric together with tamarind fruit pulp. The color of curcumin from turmeric is pH dependent, and the color at acidic pH is bright yellow [10]. However, the color of *kunyit asam* is brownish yellow because of palm sugar (Fig. 1). The taste of this drink is sour, resulting from tamarind, earthy, quite bitter, and slightly peppery spice from curcumin. Currently, this herbal drink is also consumed as a refreshing beverage [11].

Beras kencur has a slightly yellowish milky appearance from ground aromatic ginger and ground roasted rice. During storage, precipitation occurs because of the water insolubility of its ingredients. The serving suggestion is to shake the drink before consumption. The taste of this drink is sweet, and warm, and has a slightly spicy flavor from aromatic ginger. The roasted rice provides energy from its nutritional compounds and contributes to the desirable viscosity because the boiling process will gelatinize the rice starch. *Beras kencur* has sensory attributes of sweet taste, warm sensation, and sweet aftertaste. The sensory emotions produced by *beras kencur* are happiness, enthusiasm, and good emotions. *Beras kencur* drink should own several sensory profiles including warm sensation and sweet taste [12].

Sinom is made from young tamarind leaves, yellow mangosteen, and turmeric. Both have a sour taste and contribute to the refreshing sensation of the drink. This product has a bright yellowish-brownish color and low viscosity. During preparation, the tamarind leaves are boiled with turmeric and yellow mangosteen in which the bioactive compounds might be extracted, and contribute to the color and taste of the product. Palm sugar also contributes to the brownish color and specific pleasant taste. The profiling study of Dwihindarti [13] showed that there were 19 attributes of *sinom* and *kunyit asam*, including sweetness, saffron specific aroma, sourness, sourness aroma, saffron after flavor, bitterness, texture/mouth feel astringent, texture/mouth feel of viscosity, after feel astringent, after taste sourness, orange color, brown color, and after taste bitterness.

Wedang jahe and *wedang pokak* are usually served in warm condition and have a spicy taste from ginger and a brownish color. Both herbal drinks have similar ingredients. Its main ingredient is ginger, which is warm and spicy. Although ginger is the main ingredient for *wedang jahe*, other ingredients are cinnamon, clove, Javanese cardamom, pandan leaves, and cane sugar. The difference between both is the use of turmeric and curcuma for *wedang jahe* and lemongrass stalks, nutmeg, and palm sugar for *wedang pokak*. Palm sugar contributes to the darker color of *wedang pokak*. *Wedang jahe* has a high intense ginger taste, reddish color, pungent and warm sensation, warm after-feel, and pungent aftertaste [14].

Health benefits of herbal drink ingredients

Some of the herbs, such as ginger, turmeric aromatic ginger, lemongrass, cinnamon, and nutmeg, used as the main ingredients of traditional herbal drinks have been studied intensively to explore their bioactive compounds and health benefits. However, some have not been explored deeply, such as sappan wood, tamarind pulp and leaves, cardamon, nutmeg, pandan leaves, lime leaves, bay leaves, and cloves. The literature on the bioactive compounds and health benefits of the main ingredients of traditional herbal drinks are summarized in Table 3.

Table 2 Ingredients and processing of traditional herbal drinks

Herbal drink	Ingredients and formula	General processing
Kunyit Asam	Turmeric (10–15%), tamarind fruit pulp (5–10%), palm sugar to taste, cane sugar to taste, water	Turmeric is washed clean, thinly sliced, and ground. Ground turmeric is cooked using water. Tamarind fruit pulp is added to the turmeric solution and cooked again until boiling. The drink is cooled and filtered utilizing a cloth sieve and ready to drink
Beras Kencur	Aromatic ginger (20–30%), tamarind fruit pulp (5–10%), palm sugar to taste, cane sugar to taste, raw rice (no information), water	The aromatic ginger is ground until smooth. Raw rice is roasted and ground. All ingredients are mixed and boiled. The drink is filtered and ready to serve
Sinom	Young tamarind leaves (2–3 bunches), palm sugar to taste, cane sugar to taste, yellow mangosteen (40–60 g), turmeric (no information), water (2 L)	Tamarind leaves, sliced brown sugar, yellow mangosteen, and water are mixed and cooked until boiling, cooled and filtered using a sieve to get the *sinom* drink
Wedang Uwuh	Ginger (20 g/1 knukle), sappan wood (1 knukle), Javanese cardamom (1–2 pieces), lemongrass (1/2 stalk), bay leaves (1–2 pieces), pandan leaf (1/2–1 leaf), cinnamon (1–2 segments), lime leaves (1/2–1 leaf), cloves (2–4 pieces), rock sugar to taste, water (1 glass)	Ginger is crushed, mixed with all the other ingredients, and brewed using boiling water and served with all ingredients
Wedang Jahe	Ginger (40–60%), curcuma (1–2%), turmeric (1–2%), cinnamon (0.05–1%), cloves (0.25–0.5%), Javanese cardamom (0.05–0.1%), lemongrass stalk (1–2 stalks), pandan leaves (1–2 pieces), cane sugar to taste, water	Ginger, turmeric, ginger, lemongrass stems, pandan leaves are washed thoroughly. The ginger is blended and squeezed to extract the juice and mixed with water. The remaining ingredients (apart from sugar) are mixed with the ginger juice that has been prepared previously. The mixed ingredients are boiled, cooled, and filtered to get the *wedang jahe*
Wedang Pokak	Ginger (15–25%), lemongrass to taste, pandan leaves (1–2 pieces), nutmeg (0.5–1%), cinnamon (0.5–1%), cloves (0.25–0.5%), Javanese cardamom (0.25–0.5%), cane sugar to taste, palm sugar to taste, water	Ginger is ground and squeezed to have the ginger juice, and cooked until boiling. Separately, bruised lemongrass and pandan leaves are boiled. The remaining ingredients (except sugar) are blended using the remaining water. All ingredients and sugar are then mixed and cooked until boiling, cooled, and filtered to have the *wedang pokak* drink

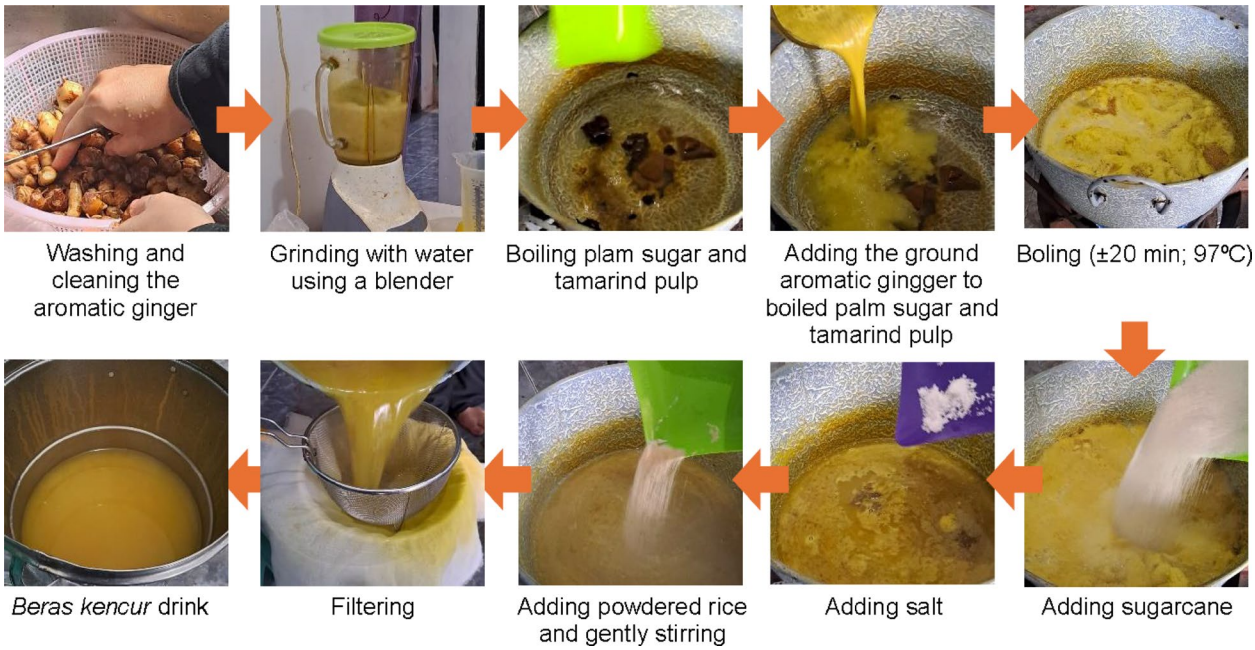

Fig. 7 A typical *beras kencur* making in a household industrial scale herbal drink maker (personal documentation)

Fig. 8 A typical *kunyit asam* making in a household industrial scale herbal drink maker (personal documentation)

Table 3 Bioactive compounds and health benefits of the main ingredients of Indonesian traditional herbal drinks

Ingredients	Herbal drink	Bioactive compounds	References	Health benefits	References
Turmeric	*Wedang jahe, kunyit asam, sinom*	Curcumin, dimethoxy, bisdemethoxy-curcumin, essential oils, β turmerine, phenolic compounds	[15–18]	Anti-inflammatory, antimicrobial, antirheumatic, anti-bias, antidiabetic, antihepatotoxic, and anti-cancer activity	[15–18]
Tamarind fruit pulp	*Kunyit asam, beras kencur*	Saponins, alkaloids, glycoside Flavonoids	[19, 20]	Antioxidant, antibacterial, analgesic, and inflammatory effect	[20–22]
Aromatic ginger	*Beras kencur*	Galangin, essential oil, flavonoid, phenol, limonoid, and tannin	[23–26]	Antioxidant, antimicrobial, analgesic, anti-inflammatory, sedative, vasorelaxant, antiprotozoal and wound healing activity	[27]
		Terpenoids, phenolics, cyclic dipeptides, flavonoids, diarylheptanoids, fatty acids and esters, polysaccharides, others	[28]	Antitumor, anti-inflammatory, antioxidant, anti-sunburn, antimicrobial, vasodilatory, anti-angiogenic, anti-osteoporosis activities	[28]
		Essential oils comprised with major constituents were ethyl trans-p-methoxycinnamate, ethyl cinnamate, pentadecane, 1,8-cineole γ-car-3-ene, borneol, and terpenoid	[29]		
Rice	*Beras kencur*	Flavanols, flavanone, γ-oryzanol, and chlorogenic acid	[30]	Antioxidant, anticancer, antidiabetic, anti-inflammatory, and other medicinal uses	[31]
Tamarind leaf	*Sinom*	Organic acids, polyphenols, flavonoids, nonphenolic bioactive	[32, 33]	Antioxidant, antiperoxidative, antihyperlipidemic, antihyperglycemic, analgesic activity, anti-inflammatory and antinociceptive	[32–36]
Yellow mangosteen	*Sinom*	Benzophenones, xanthones, flavonoids	[37]	Antimicrobial activity	[37]
		Prenylated acylphloroglucinols	[38]	Inhibitory activities against hepatocellular carcinoma	[38]
				Cytotoxic and anti-inflammatory activity	[39]
Ginger	*Wedang uwuh, wedang jahe, wedang pokak*	Essential oil (gingerols, shogaols, and zingerone)	[40]	Antiemetic, antioxidant, anti-inflammatory, antinociceptive, and antiproliferative activity	[41]
Lemongrass	*Wedang uwuh, wedang jahe, wedang pokak,*	Terpenoids (cymbopogonol and cymbopogone), flavonoids, phenolic compounds, essential oil	[42–44]	Antioxidant, antibacterial, antiviral, antifungal, antioxidant, anticancer activity, and miscellaneous	[45, 46]
Curcuma	*Wedang jahe*	α-Curcumene, β-curcumene as the main constituents, curzerene, camphor, xanthorrhizol as a significant fraction the curcuma essential oils	[47]	Antibacterial activity against Gram positive pathogens	[47]
				Ethanol extract and xantorrizhol may act as an anticancer and chemopreventive agent	[48]
				Antibacterial, anti-inflammatory, antioxidative, nephroprotective, antitumor, neuroprotective, hepatoprotective activities	[49]

Table 3 (continued)

Ingredients	Herbal drink	Bioactive compounds	References	Health benefits	References
Sappan wood	*Wedang uwuh*	Phenolic acid, flavonoids, anthraquinones, Brazilin	[50–52]	Antioxidant, antibacterial activity, antiacne, anti-inflammatory, hypoglycemic activity, vasorelaxation activity, hepatoprotective activity, antimicrobial, antiviral, antiparasitic activity, anti-arthritic activity, neuroprotective activity, and miscellaneous	[51, 52]
Pandan leaf	*Wedang uwuh, wedang jahe, wedang pokak*	Terpenoid, alkaloid, anthraquinone glycoside, cardiac glycoside, saponins, tannins, flavonoids, chlorophyll, and essential oil	[53–55]	Antidiabetic, antibacterial, anti-antiviral, antioxidant, antihyperglycemic, and anticancer activity	[56]
Cinnamon	*Wedang uwuh, wedang jahe, wedang pokak*	Phenolic, flavonoid compounds, essential oil	[57–60]	Immunomodulatory, antibacterial, antifungal, antidiabetic, antioxidant, anti-inflammatory, α-glucosidase inhibitory, anticancer, anti-dyslipidemia, anti-hyperuricemia, and cardiovascular protective activities	[58, 61–63]
Clove	*Wedang uwuh, wedang jahe, wedang pokak*	Phenolic compounds, essential oil (eugenol and eugenol acetate)	[64–67]	Anti-inflammatory, antiviral, antifungal, anticancer, antiseptic, analgesic, antioxidant, antidepressant, antispasmodic, and antibacterial properties	[64, 67, 68]
Indonesian bay leaf	*Wedang uwuh*	Flavonoids, tannins, eugenol, steroids, alkaloids, triterpenoids, essential oils	[69]	Wound healing, antioxidant, anticonvulsant, analgesic, anti-inflammatory, antimutagenic, immunostimulant, antiviral, anticholinergic activity	[69]
		Myricetin-3-O-rhamnoside (myricitrin), epigallocatechin-3-gallate	[70]	α-glucosidase inhibitors	[70]
Javanese cardamom	*Wedang uwuh, wedang jahe, wedang pokak*	Flavonoids, terpenoids, diarylheptanoids, coumarins. Triterpenes and flavonoids are the main constituents	[71]	Anti-Asthmatic	[72]
Nutmeg seed	*Wedang pokak*	Terpenoids, tannins, alkaloids, flavonoids, phytates, oxalates, saponins, steroids, glycosides, phenolic compounds, resins, and essential oil (myristicin, elemicin, safrole, and isoeugenol)	[73–76]	Antibacterial, anti-inflammatory, anticancer, antimalarial, anticonvulsant, hepatoprotective, antiparasitic effects chemo-preventive agent, anti-anxiolytic, and anti-helmintic effects	[77, 78]
Kaffir lime leaf	*Wedang uwuh*	Alkaloid, flavonoid, terpenoid, tannin, saponins	[79]	Kaffir lime extract reduces the viability of cervical and neuroblastoma cell lines	[79]
		Coumarins, phenolic acids, flavonoids, and terpenoid	[80]	Antimicrobial, anti-mosquito, antioxidant, anti-tumor, anti-inflammatory and neural-protective activity	[80]

Turmeric (*Kunyit, Curcuma longa*)

Turmeric (*Curcuma longa*) is a *Zingeberaceae* family [18] of medicinal plant in the form of rhizomes or an *empon-empon*. The color of turmeric is yellow, thus it is used as a natural coloring agent in cooking, which is widely used in Indonesian traditional dishes such as *nasi uduk*, *tumpeng*, fish or chicken curry, and seasonings in various yellowish foods. Turmeric has a distinctive taste as a spice, and this plant is easily cultivated using its rhizomes. Turmeric is one of the most important and long-known medicinal plants [81]. Turmeric rhizome is widely used in medicine and has potential as a treatment for various diseases, such as anti-inflammatory, antimicrobial, antirheumatic, antidiabetic, antihepatotoxic, and anticancer agents. The rhizome of turmeric contains various compounds, including non-volatile curcuminoid bioactive compounds (curcumin, dimethoxy, and bisdemethoxy-curcumin) and compounds present in essential oils (mono- and sesquiterpenoids). The curcuminoids are used widely in traditional,edicine and in foods as flavoring agent and acrid condiments in Southeast Asia [15].

Curcuminoid extracts exhibit potent antioxidant, anti-inflammatory, and antimicrobial activity when used medicinally for the prevention and treatment of chronic diseases. Curcuminoids are also potential therapeutic agents in diseases such as atherosclerosis, neurodegenerative diseases, and certain types of cancer. In addition, curcuminoids have been widely used as traditional medicines, spices, and antiseptics in Southeast Asia. Thus, the antioxidant and antimicrobial properties of curcuminoids play a key role in preventing and treating chronic inflammatory diseases, and we derive these benefits from our daily diet using turmeric as a spice or herbal medicine [18]. Turmeric also contains a antioxidant protein with a molecular weight of 34 kDa called β-turmerin, which has the ability to capture reactive oxygen species (ROS) [16]. Turmeric also contains a number of phenolic compounds that have the ability to act as antioxidants and anticancer [73].

Curcumin is a curcuminoid found in turmeric. Many in vitro and in vivo studies have shown that curcumin has a great potential to treat various inflammatory diseases [15]. Turmeric or curcumin has important value as a complementary therapy (additional) in metabolic syndrome [82]. Curcumin also plays a role in reducing ROS (*reactive oxygen species*), increasing pro-apoptosis and anti-inflammation, and reducing signaling for the regulation of cancer cell growth. The combination of these various roles is a result of turmeric as an anticancer [83]. Curcumin is a prospective compound for preventing liver disorders related to oxidative stress. Treatment with curcumin increased endogenous levels of antioxidants (ascorbic acid, glutathione peroxidase/GSH, superoxide dismutase/SOD, and catalase/CAT) in the liver [15].

Tamarind (*Asam Jawa, Tamarind indica*) fruit pulp

Tamarind indica, sometimes known as tamarind, is a tropical leguminous evergreen tree belonging to the *Caesalpiniaceae* subfamily of the Fabaceae family that can be found throughout Southern Asia and Africa. Tamarind fruit pulp comprised 30–50% of the total fruit [84]. The tamarind fruit pulp is one of the ingredients used in Indonesian cuisines, such as *sayur asem* and *rujak,* to improve their taste and give a freshness effect [85]. Due to its freshness effect, tamarind fruit pulp is one of the essential ingredients to produce *jamu*. Tamarind fruit pulp contains phytochemical compounds, such as saponins, alkaloids, and glycosides [19]; and flavonoids, such as procyanidins, catechin, taxifolin, apigenin, luteolin, and naringenin [20]. The bioactive compounds in tamarind fruit pulp have also and attractive attention in the medical field due to their various pharmacological properties. The water extract of tamarind pulp has an analgesic effect in rats by triggering the opioidergic system in both the peripheral and central nervous systems [20, 22]. In vivo studies showed that the flavonoid-rich tamarind pulp extract revealed an inflammatory activity in various metabolic inhibition pathways [20].

Tamarind (*Asam Jawa, Tamarind indica*) leaf

As much as 30% of tamarind leaves are used to produce *jamu sinom* and the rest are used as animal feed [85]. Tamarind leaves are rich in organic acids, which contribute to their taste. The organic acids found in the tamarind leaves are oxalic acid, tartaric acid, malic acid, and citric acid [32]. Moreover, the tamarind leaf extract also contains high polyphenol and flavonoid compounds [33].

The bioactive compounds in tamarind leaf extract, such as polyphenols, flavonoids, and nonphenolic compounds, have various pharmacological activities and benefits for human health, such as antibacterial and antifungal activities. Phenolic substances such as phenolic acids and flavonoids in tamarind extracts may cause this inhibitory activity [33]. The alcoholic and aqueous extract of tamarind leaves has the potential for anthelmintic activity on human health due to the presence of tannins [86]. The addition of tamarin leaf to the diet significantly improved the lipid and carbohydrate profiles, as shown by the simultaneous improvement of the antioxidant profiles of rat hepatic and renal tissues; decreased plasma glucose, lipid, and lipid peroxidation levels; and increased hepatic glycogen, hexokinase activity, and cholesterol excretion. This indicates that tamarind leaf has a potential and a capability as an antioxidant, antiperoxidative, antihyperlipidemic, and antihyperglycemic agents [34]. According

to Goyal et al. [35], tamarind leaves dramatically reduced λ-carrageenan-induced paw edema. These activities were due to the flavonoid compound in the hydroethanolic of tamarind leaves. It possesses anti-inflammatory and antinociceptive potential in human health [36].

Aromatic ginger (*Kencur, Kaempferia galanga* L)

Aromatic ginger belongs to the *Zingiberaceae* family, has potential medicinal properties, and is well-known for its use as a medicine and spice. The information on the scientific and chemical characteristics of bioactive compounds in aromatic ginger was very limited. Despite of that, Wang [28] reviewed the phytochemistry of aromatic ginger, which comprised of secondary metabolite bioactive compounds shown in Table 3. This rhizome also rich in essential oils generally consisted of hydrocarbons, esters, aromatic compounds, and terpenes, with the major constituents is cited in Table 3 [29]. The constituents from aromatic ginger have wide pharmacological properties, such as antioxidant, antimicrobial, analgesic, anti-inflammatory, sedative, vasorelaxant, nematocidal, insect repellent, larvicidal, antiprotozoal, and wound healing activities [27]. This rhizome has been extensively used in traditional medicine such as treatments for dry cough, rheumatism, muscle pain, colic, tumors, and inflammations in China, and for intestinal wounds and urticarial in India.

In Malaysia, aromatic ginger is used for postpartum care and abdominal pain [28]. In Indonesia, the rhizomes and leaves of this plant are used to treat coughs, common colds, headaches, wounds, ulcers, asthma, breast cancer, and after-childbirth treatment [87]. Modern pharmacological studies revealed that the aromatic ginger extracts exhibited comprehensive bioactivities, including antioxidant, antitumor, anti-inflammatory, and anti-tuberculosis [28].

Sappan wood (*Kayu Secang, Caesalpinia sappan*)

Caesalpinia sappan L., commonly known as sappan, Brazil wood, and *suou*, is a wood most frequently found in Southeast Asia and the Pacific Islands [50]. Sappan wood has been traditionally used as an antibacterial, anti-inflammatory, antitumor, immunomodulator agents, natural dye, and traditional herbal medicine [88]. In Indonesia, sappan wood is served by brewing with boiling water, such as making tea, and it is the essential component of traditional herbal beverages, such as *wedang uwuh* [89].

Phenolic acid, flavonoids, and anthraquinones are the significant constituents of sappan wood. Nevertheless, sappan wood also contains other minor constituents, such as alkaloids, tannins, and terpenoids [50]. The water-soluble flavonoids brazilin, protosappanin, and hematoxylin are rich in sappan wood, with brazilin as the primary homoisoflavonoid component, which is well-known as a natural red dye [49]. The brazilin has numerous pharmacological activities, such as antioxidant, antibacterial, antiacne, anti-inflammatory, hypoglycemic, vasorelaxation, hepatoprotective, antimicrobial, antiviral, antiparasitic, antiarthritic, and neuroprotective activities [51, 52].

Ginger (*Jahe, Zingiber officinale*)

Ginger (*Zingiber officinale* Roscoe), is a member of *Zingiberaceae* family, has more than 400 bioactive compounds, and its oleoresin consists of non-volatile components such as phenolic compounds, including gingerols, shogaols, zingerone [40], and various potentially bioactive substances, including gingerol, shogaol, zingerone, and paradol. Among the gingerols and shogaols, the main spicy components in the rhizomes are 6-gingerol and 6-shogaol [90].

Ginger is widely used as a cooking spice and also used for treatment of various diseases. Many pharmacological studies revealed that ginger has broad health benefits, such as antiemetic (prevents vomiting and nausea), antioxidant, anti-inflammatory, and antinociceptive or pain reliever (analgesic), relieving menstrual pain (dysmenorrhea pain), treating ulcerative colitis, and antiproliferative activity against various types of cancer cells, such as breast, prostate, pancreatic, colon, and colorectal (colon) cancers. The healthy properties of ginger are often associated with components in ginger, such as gingerols and shogaols, which have a spicy taste. Fresh rhizomes contain high level of gingerols, which are converted to shogaols by heating or drying processes [41]. Another health benefit of ginger that has been known for a long time is to treat inflammation, gastrointestinal disorders, diabetes, cancer, obesity and metabolic syndrome [91].

Lemongrass (*Serai, Cymbopogon citratus*)

Lemongrass is an aromatic grass that belongs to the *Poaceae* family and genus Cymbopogon *which* contains essential oils with a delicate lemon flavor [92]. Due to its flavor, lemongrass is used as a flavoring compound in Asian cuisines, including in Indonesian foods and beverages [93]. Similar to other herbal plants, lemongrass is rich in phytochemical bioactive compounds such as terpenoids, flavonoids, phenolic compounds, and essential oils [42]. Polyphenolic compounds such as 7-O-glycosides, luteolin, flavonoids, apiginin, kaempferol, caffeic acid, catechol, hydroquinone, and elimicin have been isolated and characterized from lemongrass. Furthermore, in their fresh leaves, lemongrass is also rich in cymbopogonol and cymbopogone, which belong to terpenoid groups [43]. The delicate lemon flavor in lemongrass

correlated with its essential oil. Geranial was the principal constituent in lemongrass oil, followed by neral, geranyl acetate, caryophyllene, trans-geraniol, linalool, 6-methyl-5-heptan-2-one, camphene, and caryophyllene oxide in sequence [44]. Apart from these, the bioactive compounds in lemongrass have various medicinal properties. The lemongrass extract can act as an antioxidant by reducing LDL (low-density lipoprotein) oxidation and scavenging ROS and does not alter the bioavailability of NO (nitric oxide), thus causing vasodilation in precontracted venous rings [45]. The lemongrass essential oil also has health benefits, such as antibacterial, antiviral, antifungal, antioxidant, anticancer activities, and miscellaneous [46].

Clove (*Cengkeh*, *Syzygium aromaticum*)

Clove is a native and precious spice from the Moluccas Islands in the eastern region of Indonesia with abundant health benefits [68]. This herb is a family of *Myrtaceae*. Clove contains large amounts of phenolic compounds, including flavonoids, hydroxycinamic acids, hydroxybenzoic acids, and hydroxyphenyl propenes. Caffeic, ferulic, elagic, and salicylic acids are also found in clove. Flavonoids such as kaempferol, quercetin, and their glycosylated derivatives are also present in trace amounts [64, 65]. The aromatic and unique odor of clove buds came from their essential oil, with comprising of 18% based on clove bud flowers [68]. Worldwide, numerous cultures use clove essential oil for food preservation and traditional medicine to cure tooth infections, burns, and other wounds [94].

Eugenol and its derivative, eugenol acetate, are the main bioactive compounds of clove essential oil [66]. Eugenol, which makes up more than 50% of the volatile oil in clove, has a variety of pharmacological effects. Another bioactive compound in the essential oil of clove buds is eugenol acetate [67]. Furthermore, clove and its essential oils, especially eugenol and its derivatives have anti-inflammatory, antiviral, antifungal, anticancer, antiseptic, analgesic, antioxidant, antidepressant, antispasmodic, and antibacterial properties [64, 67, 68]. Clove also has health benefits to stop diarrhea and relieve stomachache and nausea [95].

Cinnamon (*Kayu Manis*, *Cinnamomum verum*)

Cinnamon bark is a flavorful spice belongs to the family of *Lauraceae*, that is well-known worldwide, including in Indonesia, and can be used in culinary and traditional medicine. It is made from the inner bark of the *Cinnamomum* spp. tree [96]. Cinnamon bark is added to various foods as a flavoring compound, usually in powder form [60]. In traditional medicine, cinnamon bark is used for treatments of diarrhea, fever, common cold, toothache, nausea, flatulence, amenorrhea, headache, cough, and numerous other symptoms [97]. Phytochemically, the water extract of cinnamon bark is rich in tannins, phenolic compounds, resin, flavonoids, saponin, alkaloids, coumarins, and terpenes [98].

Cinnamon bark is abundant in phenolic and flavonoid compounds such as catechin, procyanidins, quercetin, epicatechin, and phenolic acids, including protocatechuic acids, p-coumaric acids, p-hydroxybenzoic acid, syringic acid, rosmarinic acid, chlorogenic acid, ferulic acid, and caffeic acids [57, 58]. Cinnamon essential oil has abundant bioactive compounds, dominated by cinnamaldehyde, transcinnamaldehyde, and eugenols [58–60]. Bioactive compounds in cinnamon bark have various pharmacological properties, such as immunomodulatory, antibacterial, antifungal, antidiabetic, antioxidant, anti-inflammatory, α-glucosidase enzyme inhibitory, anticancer, antidyslipidemic, antihyperuricemic activities, and cardiovascular protection [58, 61–63, 99].

Nutmeg (*Pala*, *Myristica fragrans*) seed

Nutmeg, one of the *Myristicaceae* family, is an indigenous plant of Indonesia, where the Moluccas Islands, specifically Banda Island, Siau, North Moluccas, and Papua, having a central genetic origin and genetic diversity [100]. Nutmeg seeds are commonly used as spices for seasoning and traditional medicine. In Indonesian cuisine, nutmeg is used in various recipes, especially for soupy dishes such as soto, *konro*, meatballs, oxtail, rib, and goat soup [100]. As a traditional medicine, nutmeg is used as a heartburn medicine [101].

Earlier studies reported that the nutmeg seed contained abundant phytochemical compounds such as terpenoids, tannins, alkaloids, flavonoids, phytates, oxalates, saponins, steroids, glycosides, phenolic compounds, and resins, and its availability was dependent on the extracting solvent [74, 76]. Nutmeg seeds also contain rich essential oils, giving them a distinctive aroma. The essential oil in nutmeg consists of aromatic ethers, terpenes, monoterpene alcohol, sesquiterpene, terpinic esters, and acids [73], with specific pharmacological activities. Numerous investigations have shown that nutmeg seed essential oil has biological properties, including insecticidal, antibacterial, anti-inflammatory, anticancer, antimalarial, anticonvulsant, hepatoprotective, and antiparasitic effects [77]. Myristicin is one of the bioactive compounds in nutmeg oil and has various bioactivities, such as a chemopreventive agent and hepatoprotective, anti-anxiolytic, and anthelmintic effects. However, the conversion of myristicin to its active metabolic structure of 3-methoxy-4,5 methylenedioxy amphetamine (MMDA) is believed to be capable of causing hallucinogenic effects after nutmeg consumption [78].

Pandan (*Pandan*, *Pandanus amaryllifolius*) leaf

Pandan is a native to Indonesia and tropical plant with a unique aroma. This plant belongs to the *Pandanaceae* family and is found abundantly in Indonesia. This plant is easy to cultivate and often found in home gardens, and the leaves are commonly used as a natural colorant and aromatic flavor in several traditional foods and beverages [102]. Pandan leaf is a food ingredient that is rich in phytochemical compounds such as terpenoids, alkaloids, anthraquinone glycosides, cardiac glycosides, saponins, tannins, and flavonoids [103]. Moreover, pandan leaves are also rich in green pigments, known as chlorophyll [55] and essential oils [54]. Pandan leaves have 54 components, with phytol as the main constituent of essential oil [54]. The bioactive compounds of pandan leaves have various pharmacological activities, such as antidiabetic, antibacterial, antiviral, antioxidant, antihyperglycemic, and anticancer activities [56].

Several previous studies widely investigated the health benefits and disease prevention of pandan leaves. The water extract of pandan leaves was effective in protecting against liver damage in rats by reducing biochemical markers of liver injury and improving antioxidant enzyme activity. These hepatoprotective effects were attributed to phytochemical constituents, such as tannins, alkaloids, saponins, flavonoids, and terpenoids, in the pandan leaf extract [104]. The pandan leaf essential oil revealed antibacterial activity, both in Gram positive bacteria and Gram negative bacteria, with the most potent inhibitory effects observed on *E. coli* in Gram-negative bacteria and *M. luteus* in Gram-positive bacteria [54].

Indonesian bay leaf (*Daun Salam*, *Syzygium polyantum*)

Bay leaf is a medicinal plant widely grown in South Countries and belongs to the *Myrtaceae* family [105]. Indonesian bay leaves are commonly used as a spice in Indonesian cuisine and as traditional medicine, especially for treating diabetes mellitus, skin disease and infection, diarrhea, ulcers, gastritis, hypertension, and many more [106–108]. Ethanolic Indonesian bay leaf extract is rich in phytochemical constituents, including alkaloids, flavonoids, tannins, quinone, and terpenoids. The abundance of phytochemical compounds in bay leaf extract depends on the concentration of extracting solvent [107]. The essential oil of Indonesian bay leaf contains squalene and phytol as the major compounds. Other bioactive compounds are hentriacontane, palmitic acid, α-pinene, nerolidol, linalool, α-tocopherol, and β-tocopherol [109]. Indonesian bay leaf is also interesting to use in medicine due to its properties, such as antioxidant, antidiabetic, antihypertensive, antimicrobial, antidiarrheal, anticancer, antitumor, dental plaque inhibition, lipid-lowering, and acetylcholine-esterase inhibitor properties [106].

White rice (*Beras*, *Oryza sativa*)

Rice is a primary staple food grown and consumed in all Asian countries and half of the world's population [110]. White rice is also an ingredient for making Indonesian herbal drinks, such as *beras kencur* [111]. White rice contained lower quantities of phytochemicals, in the form of flavones/flavonols and γ-oryzanol, together with trace levels of the carotenoids lutein and zeaxanthin than red rice [28]. The bioactive compounds in rice have nutraceutical potential as antioxidants and have anticancer, antidiabetic, anti-inflammatory, and other medicinal uses [29].

Javanese cardamom (*Kapulaga*, *Amomum cardamomum*)

Javanese cardamom seed (one of *Zingiberaceae* family) with Indonesian name *kapulaga*, is one of the most expensive and exotic spices native to Indonesia. It is widely distributed and grown wild in Java forests [112]. It is commonly used as a flavoring agent in various foods and ingredients for Indonesian herbal beverages, such as *wedang uwuh, wedang jahe,* and *wedang pokak*. Globally, cardamom is used in various foods and beverages, including tea, coffee, snacks, rice, sweet dishes, and many more [113]. Javanese cardamom is rich in triterpenoids, essential oils, steroids, and flavonoid compounds [114]. Cardamom contains other bioactive compounds and gives a unique and pleasant aroma known as essential oil, which is dominated by cineole. α-Pinene, β-pinene, camphene, limonene, β-cymene, α-terpineol, and α-humulene are other essential oil components. Cardamom is also used as a traditional medicine for aiding digestion and having aphrodisiac effects on the gut [115]. Cardamom is one of the spices used as an immunity booster during the COVID-19 pandemic [116]. Cardamom also has other pharmacological bioactivities, such as immunomodulatory, anti-inflammatory, antioxidant, antidote, hepatoprotective, antiulcerogenic, antibacterial, anticancer, antiasthmatic, antifungal, and antiallergic activities [71, 112, 113, 116].

Kaffir lime (*Jeruk Purut*, *Citrus hystrix*) leaf

Kaffir lime is a lime species from family of *Rutaceae*, native to southern China and Southeast Asia. Some Indonesian cuisine uses kaffir lime leaves, such as chicken *soto*, fish curry, and *rawon*. In Malaysia and Brunei, the leaves are also used for tea and flavoring [80]. Kaffir lime leaf essential oils exhibit antibacterial potency and antibiofilm formation produced by microbes. Kaffir lime oil leaf extract disrupted the bacterial outer membrane. Citronellal is one of the essential active constituents of kaffir lime oils [117]. Kaffir lime leaf extracts contain carbohydrates, alkaloids, glycosides, flavonoids, steroids, phenolic compounds, and tannins. These extracts have antioxidant activities to scavenge free radicals and

antitumor potency [79]. The antiproliferative and cytotoxic potential of kaffir lime extract is attributed to the essential oils [118]. Agrostophillinol from kaffir lime leaves has anti-inflammatory activity [119, 120]. Some investigations patented the use of kaffir lime extract for skin care and hair damage treatment because of its antioxidant activity as a radical scavenger for skin and hair damage protection and treatment [80].

Curcuma (*Temulawak*, *Curcuma xanthorrhiza*)

Curcuma, locally named *temulawak*, as one of the *Zingiberaceae* family, has been extensively used in Indonesia for medicinal and nutritional purposes for a long time. The curcuma rhizome is an important ingredient of *jamu*. Traditionally, curcuma is used to treat several symptoms, such as lack of appetite, liver disease, stomach disorder, bloody diarrhea, arthritis, constipation, dysentery, fevers, hypotriglyceridemia, vaginal discharge, hemorrhoids, skin irritation, and rheumatism. Over 40 active compounds, including curcuminoids, terpenoids, and other phenolic compounds, are found in curcuma. Some pharmacological studies have reported that curcuma has antimicrobial, antioxidant, anticancer, anti-inflammatory, antidiabetic, antitumor, and hepatoprotective properties [49]. The essential oils of curcuma exhibit antibacterial and antibiofilm activities; thus, these rhizomes are traditionally used to treat infectious diseases. The principal constituents of curcuma are α- and β-curcumene, camphor, and curzerene; and xanthorrhizol is also found in significantly lower quantities [47].

Yellow mangosteen (*Asam Kandis*, *Garcinia xanthochymus*)

Yellow mangosteen or gamboge is a tropical plant from the *Clusiaceae* (*Guttiferae*) family [38]. The predominant phytochemicals in yellow mangosteen are xanthones, flavonoids, benzophenones, isocoumarins, and depsidones [37]. The dry fruit of yellow mangosteen contains xanthochymusones J–M, prenylated acylphloroglucinols, garciniagifolone A (5), and garcinialiptone A (6) [38]. Brito et al. [121] reported the major bioactive components of yellow mangosteen, including isogarcinol, garcinol, xanthochymol, hydroxycitric acid, cycloxanthochymol, isoxanthochymol, guttiferone isoforms, camboginol, garsubellin, gambogic acid, mangostin, and kolaviron. These phytochemicals contribute to antidiabetic, antioxidant, antimicrobial, and cytotoxic activities [37]. In China, yellow mangosteen is used for malignant lymphoma and breast carcinoma treatment. Xanthones are considered to have anticancer activity, mainly due to their cytotoxicity to various cancer cell lines, even at low concentrations [121].

Health benefits of traditional herbal drinks: perception and scientific evidence

The long history of *jamu* for health, in which traditional herbal drinks are part of this Indonesian traditional medicine, comes from the growing perception and belief based on empirical experiences. The belief is generated hereditary from mouth to mouth, and some are written in ancient manuscripts, such as *serat Centini*. The beliefs and perceptions regarding the health benefits of traditional herbal drinks are summarized in Table 4.

Studies on the health benefits of Indonesian traditional herbal drinks are still limited. The existing studies on the health benefits of herbal drinks are primarily published locally. The literature search for this research is shown in Table 4. The limitation on the efficacy of herbal drinks is that the studies are mostly in vitro and in vivo experiments. Further research such as clinical studies are required to strengthen the claims of health benefits.

Based on the data in Table 4, the discussions on each traditional herbal drink are as follows.

Kunyit asam

Kunyit asam is an Indonesian traditional herbal drink made from *kunyit* (turmeric) and *daging buah asam jawa* (tamarind fruit pulp) as the main herb ingredient [122, 124], with the addition of palm sugar as a sweetener [123]. Commonly, *kunyit asam* is consumed by Indonesian people, especially in East Java [111] and Central Java [126], who believe that *kunyit asam* is efficacious as an antibiotic and can prevent mouth ulcer [111].

Several previous scientific studies reported that *kunyit asam* has potential antioxidant activity. Mulyani et al. [122] reported that *kunyit asam* had antioxidant activity against 2,2-diphenyl-1-picrylhydrazyl (DPPH) of 0.032–0.053%. Meanwhile, A'yunin et al. [123] reported that the *kunyit asam* had radical scavenging activity against DPPH in the range of 55.74 to 85.29%. Furthermore, *kunyit asam* also has the potential to be an antidiabetic agent. In vitro studies revealed that *kunyit asam* can inhibit the activity of the α-glucosidase enzyme with an IC_{50} of 146.48 ppm, similar to acarbose, a diabetic drug, with an IC_{50} of 134.07 ppm. *Kunyit asam* is also used to heal lacerations after birth or reduce pain (*dysmenorrhea*) during menstruation. Consuming *kunyit asam* accelerates the healing of perineal lacerations after birth from an average of 7–10 days to 3–7 days [126]. Moreover, consuming *kunyit asam* beverages also significantly reduces *dysmenorrhea* syndrome during the menstrual period [127, 128].

The main herbal ingredients of *kunyit asam* are turmeric and tamarind fruit pulp, which have been proven to have anti-inflammatory, antimicrobial, antirheumatic,

Table 4 People's perceptions, beliefs, and scientific health benefits of Indonesian traditional herbal drinks

Herbal drinks	Health perception and beliefs	References	Scientific health benefits	References
Kunyit asam	Javanese people call this herbal medicine '*adem-ademan*' or '*seger-segeran*', which is believed to refresh the body, overcome sore throats, cool the stomach, and speed up menstruation. Additionally, it lowers blood pressure and treats constipation	[11]	Antioxidant Antidiabetic Accelerated perineal lacerations healing Reduced *dysmenorrhea* syndrome	[122, 123] [124, 125] [126] [127]
	Reducing dysmenorrheal symptom	[127, 128]		
	Antibiotics to prevent mouth ulcer	[123]		
Beras kencur	Accelerating the wound healing after birth	[129]	Antioxidant Antidiabetic Increasing appetite Wound healing after birth	[130] [131] [132] [129]
	Relaxing stiff muscles, improving blood circulation, and increasing body immunity	[133]		
	Reducing inflammation and increasing immune system	[11]		
	Relieving fatigue, preventing coughing, filter sounds, and increase appetite	[134]		
	Warming the body, speeding up wound healing, and eliminateingthe fishy smell after giving birth	[129]		
	Immunomodulator	[135]		
Sinom	Increasing the immunity	[136]	Antioxidant Antidiabetic	[137, 138] [139]
	Improving blood circulation, reducing pain during menstruation, slimming body, overcoming the problem of vaginal discharge	[124]		
	Preventing mouth ulcer and reducing body	[140]		
Wedang uwuh	Various diseases treatment such as hypertension, diabetes, heart diseases, ulcers, and increases immunity	[89]	Body weight control and blood glucose level	[141]
			Immunomodulator	[142]
			Increased SOD (superoxide dismutase) and decreased MDA (malondialdehyde)	[143]
			Antioxidant	[144]
Wedang jahe	Increasing body immunity, relieving headaches, relieving colds, warming the throat during flu and coughs	[145–147]	Immune booster Antidiabetic Anti-cholesterol Reducing *emesis gravidarum* in pregnant women Reducing *dysmenorrhea* syndrome	[129, 148] [149] [150] [151] [152]
	Warming the body, improving the respiratory system, and overcoming nausea and digestive disorders	[145]		
	Immune booster	[145–147]		
			Preventing nausea and vomiting in trimester 1 and 2 pregnant women	[153]
Wedang pokak	Increasing body immunity	[154]	No data available	

antidiabetic, antihepatotoxic, and anticancer activities (Table 3). Some symptoms are cured by these pharmacological activities, such as refreshing the body, overcoming sore throats, and reducing dysmenorrhea symptoms (Table 4), although the intercomponent interaction presumably occurs during processing as well as bioactive compound degradation and evaporation.

Beras kencur

Beras kencur is one of *jamu gendong* which is easily and widely found in Indonesia. Initially, *beras kencur* was a drink that was consumed by kings, royal families, and courtiers (*abdi dalem)* in the Surakarta Hadiningrat Palace since the eighteenth century [155]. However, it can now be consumed freely by commoners, and it is believed from generation to generation that *beras kencur* has a health efficacy to relieve fatigue, prevent coughing, filter sounds, and increase appetite [111]. Based on his interview survey, Jalil [129] revealed that *beras kencur* is believed to warm the body, speed up wound healing, and eliminate the fishy smell after birth.

Beras kencur has the potential for antidiabetic activities in humans. *Beras kencur* oral feeding reduced blood glucose levels, controlled body weight, and repaired damage to the pancreatic islets of Langerhans in streptozotocin-induced rats [131]. Moreover, oral administration of *beras kencur* to rats increased the appetite level compared to the control, which was supposed to the use of aromatic ginger as its ingredient [132]. *Beras kencur also* has inflammatory and antioxidant activities against free radicals [135]. According to Kiptiyah et al. [130], the antioxidant activity of *beras kencur* to scavenge DPPH radicals was 50.78%, and the antioxidant capacity to reduce Fe^{3+} to Fe^{2+} was 809.56 mg to 1186.92 mg ascorbic acid equivalent/L.

The ingredients of *beras kencur* are aromatic ginger and rice. Aromatic ginger, as the main ingredient, has antioxidant, antimicrobial, analgesic, anti-inflammatory, sedative, vasorelaxant, antiprotozoal, and wound-healing activities (Table 3). The traditional perception that *beras kencur* is able to relieve fatigue, prevent coughing, filter sounds, and increase appetite might be closely related to the pharmacological activities of this herb.

Sinom

Sinom is also part of the *jamu gendong*, made from *daun asam* (tamarind leaves) and kunyit (turmeric) as the main herbal ingredients. *Sinom* has been known to have many health benefits, such as preventing mouth ulcer and reducing body fat [111]. Like *kunyit asam, sinom* drink also has potential antioxidant and antidiabetic activities. *Sinom* drinks also contain bioactive ingredients in the form of flavonoid antioxidants that can prevent fat oxidation [140]. Widari et al. [124] reported that *sinom* drinks could inhibit the activity of the α-glucosidase enzyme with an IC_{50} of 231.37 ppm, which was higher than that of acarbose as a diabetic drug, with an IC_{50} of 134.07 ppm through in vitro studies.

Table 3 shows that tamarind leaf, turmeric, and yellow mangosteen have bioactive compounds with antioxidant, antiperoxidative, antihyperlipidemic, antihyperglycemic, analgesic, and anti-inflammatory activities. The analgesic and anti-inflammatory activities of these herbs prove the traditional perception that this herbal drink prevents mouth ulcer. However, the perception of body slimming requires further study to be proven.

Wedang uwuh

Wedang uwuh is made from several herbal plants with different portions and formulations, and it has various health benefits. This herbal drink is a traditional drink from the Yogyakarta Special Region of Indonesia [88]. *Wedang uwuh* is a typical herbal drink from Imogiri, Yogyakarta as the royal beverage to serve the noble guests [155]. Traditionally, *wedang uwuh* is believed to treat various diseases, such as hypertension, diabetes, heart diseases, ulcers, and to increase immunity. Table 2 shows that *wedang uwuh* has the highest number of herbs with different active compounds and bioactivities.

Table 4 shows that the herbs in *wedang uwuh* have many pharmacological activities. However, intercomponent interactions may occur during *wedang uwuh* preparation and serving. The use of brewing might also result in different pharmacological activities. The intercomponent interaction might be harmful or increase bioactivities which is still a challenge to study.

Oral feeding of *wedang uwuh* to rats considerably reduced their glucose levels and prevented obesity-related weight gain. This fact indicates the ability of *wedang uwuh* for management of blood sugar level. The rats fed a high-fat diet and beverages had decreased obesity prevalence [141]. *Wedang uwuh* also revealed inflammatory activities in alloxan-induced diabetic rats through decreasing expression of both proinflammatory cytokines, such as interferon-γ [IFN-γ] and tumor necrosis factor-α[TNF-α], and anti-inflammatory cytokines, such as interleukin 10 [IL-10] and transforming growth factor-β [TGF-ß], to achieve a balance between them [142]. Roselle-based *wedang uwuh* could decrease MDA (malondialdehyde) and increase SOD (superoxide dismutase) in cigarette smoke-exposed rats [143]. *Wedang uwuh* exhibited antioxidant capacity assayed by FRAP (Ferric Reducing Antioxidant Power), DPPH (1,1-diphenyl-2-picrylhydrazyl), and ABTS (2,2-azinobis-3-ethylbenzothiazoline-6-sulfuric acid) methods. The bio-accessibility of phenolic and antioxidant compounds in *wedang uwuh* was affected by boiling time, which 5 min boiling was better than 15 min due to phenolic compound stability during heating [144].

Wedang jahe

Wedang jahe is made from *jahe* (ginger) as the main herbal ingredient and is commonly added by other herbal plants, including curcuma, turmeric, cinnamon, cloves, Javanese cardamom, lemongrass stalk, and pandan leaf (Table 2). Traditionally, *wedang jahe* is a healthy and refreshing drink for warming the body, improving the respiratory system, and overcoming nausea and digestive disorders [146]. It is believed that *wedang jahe* is a suitable drink for immune booster during the COVID-19 pandemic [146, 147].

Kurnian [149] reported that *wedang jahe* consumption affected cholesterol metabolism and controlled cholesterol levels in diabetes mellitus patients. Oral administration of *wedang jahe* reduced blood glucose levels in female white rats fed a high-fat diet, indicating the potency of *wedang jahe* as an antidiabetic agent.

Presumably, gingerol and shogaol in ginger inhibit enzymes related to carbohydrate metabolism that induce hyperglycemia, especially α-amylase and α-glucosidase [150]. In pregnant women, *wedang jahe* was effective in reducing vomiting and nausea frequency during trimester I of pregnancy [151, 153, 156]. *Wedang jahe* is also effective in reducing *dysmenorrhea* syndrome in young women [155].

Wedang pokak

Wedang pokak is an herbal drink originating from East Java, especially Madura Island, that is similar to *wedang jahe*. *Wedang pokak* uses nutmeg, ginger, turmeric and curcuma (Table 2). The turmeric and curcuma in the formula of *wedang pokak* make this herbal drink brighter and yellowish. The ingredients of *wedang pokak* reveal some pharmacological activities and contain useful bioactive compounds (Table 3). However, this drink is still limitedly studied. The scientific evidences for the health benefits of *wedang pokak* in reputable scholarly articles are not found. We have an on-going study to evaluate the anti-inflammatory and antioxidant activities of *wedang pokak*. Traditionally, this herbal drink is believed to be an immune booster (Table 4). Further study is important to scientifically prove the health benefits of *wedang pokak*.

Several herbal drinks have similar main ingredients such as tamarind fruit pulp in *kunyit asam* and *beras kencur*; ginger, lemongrass, pandan leaf, cinnamon, clove, and Javanese cardamom in *wedang uwuh*, *wedang jahe*, and *wedang pokak*. Based on the data in Table 4 for scientifically proven health benefits, only *kunyit asam* and *beras kencur* reveal similar activity which is antioxidant and antidiabetic. The health benefit perceptions of *wedang uwuh, wedang jahe*, and *wedang pokak*, are quite similar. Although, the scientifically proven for the efficacy of *wedang uwuh* and *wedang jahe* is slightly different (Table 4), but no data is reported for *wedang pokak*. This might be due to the existing studies of *wedang uwuh* and *wedang jahe* have different focus to evaluate their health benefits. Further comprehensive studies are required to prove the similar benefits and pharmacological activities.

Transition to industrial processing of herbal drinks

Producing herbal drinks by modern processing with a tightly controlled process is still challenging. To the best of our knowledge, there is only two large-scale food industries in tetra pack packaging and polyethylene terephthalate bottle which are processed by combination of ultra-high temperature processing and aseptic packaging. Both companies produce *kunyit asam* and *beras kencur.* Other four herbal drinks are less popular than *kunyit asam* and *beras kencur*. Principles of food technology are applied in the production as well as tight control for food safety by applying GMP (Good Manufacturing Practices), HACCP (Hazard Analysis and Critical Control Point), and ISO (International Standard Organization) series.

Household and small-scale enterprises produce more varieties of herbal drinks, including *kunyit asam, beras kencur, sinom, wedang uwuh, wedang jahe*, and *wedang pokak*. The process of making these herbal drinks is simple as described in Table 2. The production is simply controlled, mainly by manual inspection without laboratory tests. Due to the limitation of processing equipment and the knowledge of herbal drink makers, these products have a short shelf-life. Although, the safety of these products is guaranteed since the Government of Indonesia obliges all food manufacturers, despite their scale, to apply GMP and the big concern to beverages.

Some critical parameters in producing herbal drinks should be established to have consistent quality and safe products. Formula of herbal drinks is the critical or quality, mainly taste and aroma, and the health benefits as well for all scale of processing. The challenge of a big food industry is the ingredients of herbal drink should be available in a quantity adequate for continuous production, and providing an intermediate and long shelf-life herbs is a problem. One big company that produced *beras kencur* used rice flour, instead of rice grain, to ease the handling without grinding. Household and small-scale industries are using fresh raw materials such as the fresh roots and leaves, since the production capacity is quite low and the material handling is simpler.

Besides formula, processing parameters affecting the quality of herbal drinks generally are temperature and time of boiling, the ratio of herbs and water, and the method of herbs size reduction and extraction. The big herbal drink industries might establish these parameters from their research, but household and small-scale enterprises determine them based on empirical experiences. The scientific establishment is required to determine the critical parameters for herbal drink production in households and small-scale enterprises. Unfortunately, the studies on this issue seem very limited as well as relevant literature, and we do not find any scholarly articles determining the critical processing parameters pf herbal drinks.

Future studies

Scientific exploration on Indonesian traditional herbal drinks is a great challenge to establish their health benefits, standardized processing, and safe products. Further studies are required thoroughly to explore more deeply the mechanism of action of herbal drink health benefits by in vitro, in vivo, and clinical studies. Herbal drink ingredient interactions during processing are also interesting to study to evaluate the synergistic

and antagonistic effects among herbal phytochemicals. Also, it is important to evaluate the effects of processing on the herbal bioactive compound stability such as time and temperature of heating. Establishing standardized processing is essential for producing herbal drinks in every processing scale. Bioactivity of herbal drinks during storage is also important to determine their shelf life. Sensory attribute profiling and consumer acceptance and preference are very important to establish as the basis for commercial herbal drink standard quality. Besides, toxicological studies are required to ensure the safety of Indonesian traditional herbal drinks.

Conclusion

This review highlights the diversity, preparation methods, and health benefits of Indonesian traditional herbal drinks, such as *kunyit asam, beras kencur, sinom, wedang uwuh, wedang jahe*, and *wedang pokak*. By integrating field observations and literature analysis, it identifies key bioactive compounds like curcumin, gingerol, and brazilin, which exhibit antioxidant, anti-inflammatory, and antimicrobial properties. The study underscores the importance of preserving traditional practices while embracing modern industrial techniques to ensure wider accessibility and consistent quality. Despite their cultural and therapeutic significance, the health benefits of these beverages remain underexplored, necessitating further scientific validation through clinical studies. This work bridges the gap between traditional knowledge and scientific inquiry, contributing to global discussions on functional foods and the sustainable development of herbal beverages.

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Author contributions
Teti Estiasih contributed to the literature search, literature analysis, figure preparation, and manuscript preparation. Jaya Mahar Maligan conducted observations and interviews with traditional herbal drink makers and provided figures. Jatmiko Eko Witoyo assisted in the literature search and manuscript preparation. Adilla Aisyah Hana Mu'alim conducted observations of traditional herbal drink makers. Kgs Ahmadi and Tunjung Mahatmanto had roles in the literature search and analysis. Elok Zubaidah contributed to supervision.

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Availability of data and materials
Not applicable.

Declarations

Ethics approval and consent to participate
This study has Ethical Approval Letter No. from The Ethical Clearance Committee on Health Sciences, Faculty of Health Sciences, Universitas Brawijaya No. 1065/UN10.F17.10.4/TU/2024.

Consent for publication
All authors agree to this publication. The herbal drink makers agree for interview, observations, and taking pictures for publication.

Competing interests
The authors declare that they have no competing interests.

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